Smart Sensors I

Multi-node Wireless Temperature Monitor

USER MANUAL

Group 164

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ECE 403
December 11, 2002

Table of Contents

List of conventions:
In this manual we emphasize depressing of a certain button on the key pad by displaying it in bold.
*Ex: **1** would mean that 1 should be depressed.*
Also the depressing of two consecutive buttons are represented by a + sign between them.
*Ex: Depressing of a sequence of **1** followed by **ENTER** would be shown as **1 + ENTER.***

BU – Base Unit

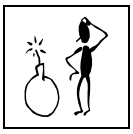
This icon identifies information on diagnosing possible problems and steps to trouble shoot them.

Components of the kit:
The following components are part of the temperature sensor kit.

1. (1) base unit
2. (4) node units
3. (8) AA size batteries
4. (1) 9V battery
5. DC 9V adapter
6. (1) serial cable
7. Software on disk

Battery Installation

In order to power up the node units, the batteries must be inserted into the case as shown in Figure 1. Ensure that the polarity of the batteries is taken into account in this step. Battery installation for the Base Unit is similar to the nodes except the AA battery holder is replaced with a 9-volt battery. Ensure proper polarity of the 9-volt battery. The Base Unit may also be powered by using the DC adapter provided.



It is extremely important to wire up the power supply to the Base Units and the nodes according to the polarity indicated. An error in this step could result in loss of the component.

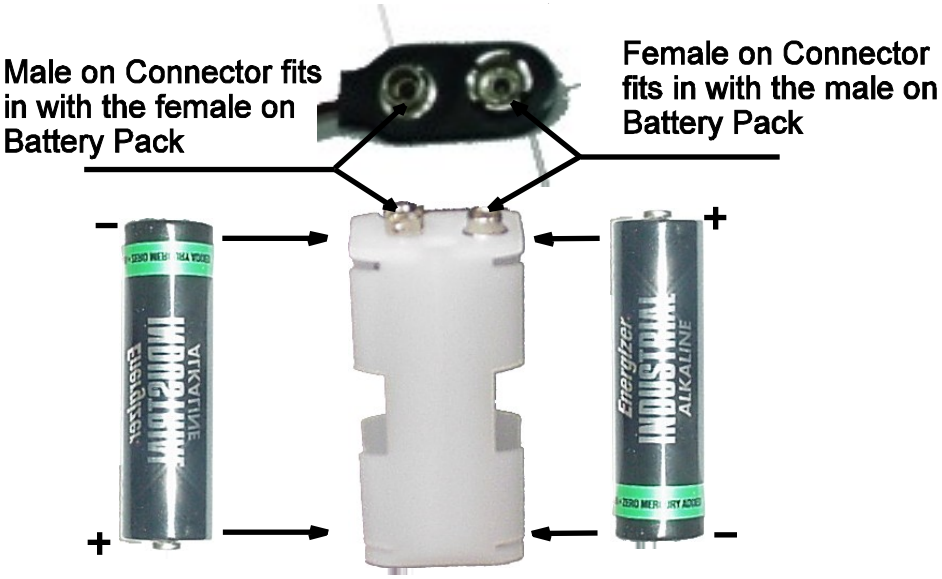


Figure 1: Inserting the node batteries

Node Layout

All the nodes must be either within wireless range of the Base Unit or within range of a node with a wireless link to the Base Unit. The range maximum range can be estimated to be about 30 feet in most surroundings. For the initial testing it would be advisable to keep them near the base unit.

Base Unit Operating System

Switch on the base unit and the following menu in the left pane will appear. The menu in the right pane can be observed by pressing the down arrow.

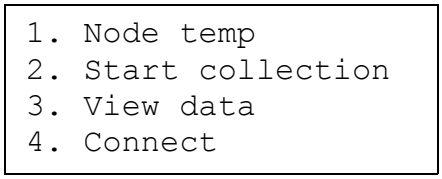
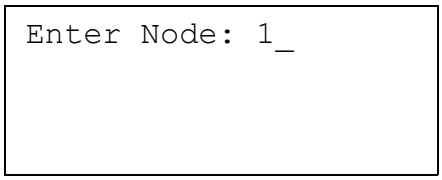
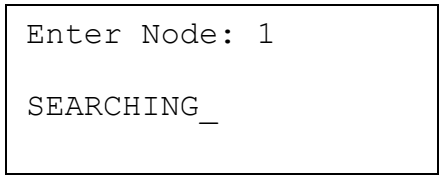
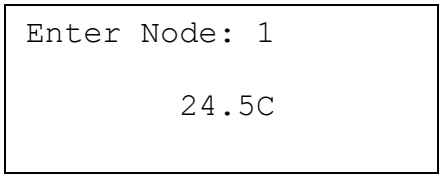
```
1. Node temp
2. Start collection
3. View data
4. Connect
```

```
5. Set clock
6. Temp alarm range
7. Delete all memory
```

1. Node temp

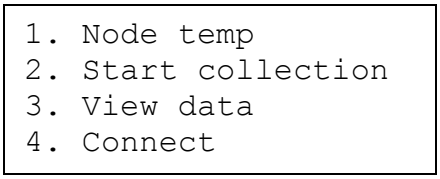
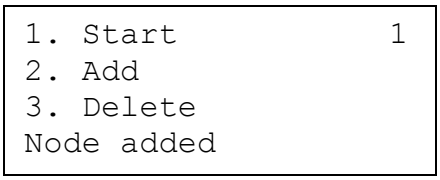
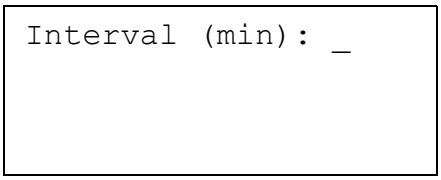
This option performs a single temperature collection from one node in the network.

Ex: If you want to poll node 1 for its temperature, you would have to do the following sequence.

Power up the BU. Ensure that node 1 is within range and is also powered up. Select option **1** to perform a single node collection.	
Now enter the number of the node that you would like to poll. Node **1** is being polled in this example.	
Now hit **ENTER** to execute the request. "SEARCHING" will be displayed to indicate that node 1 is being polled for its temperature.	
If node 1 is powered up and within range, the temperature will be displayed on the LCD. If communication with node 1 failed, "COMMUNICATION FAILURE" will be displayed on the LCD. Press any key to return to the main menu.	

2. Start collection

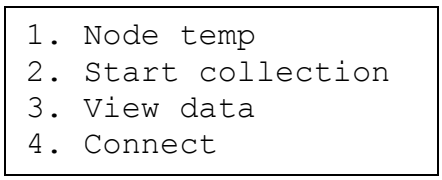
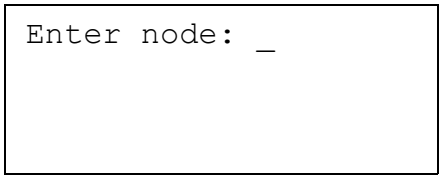
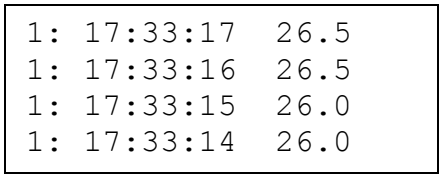
This option performs periodic temperature collection from a group of nodes. All collected temperatures along with the times of collection will be stored in memory and are available for download to a computer.

Power up the BU. Ensure that both nodes 1 and 2 are within range and are also powered up. Select option **2** from the main menu to perform a single node collection.	
The periodic temp collection menu will appear. Option 1 begins the collection, option 2 allows the user to add nodes to collect from, and option 3 allows the user to delete nodes. The nodes that will be collected from appear on the left-hand side of the LCD and be scrolled through with the up and down arrows.	
Add node 1 by pressing **2 + ENTER**. This accesses the add command. Now press **1 + ENTER** to identify and add node 1. The bottom of the screen will say "NODE ADDED" to confirm the addition, and "1" will appear in the node cache on the left side of the LCD. Repeat the previous steps to add node 2 or add and delete any nodes from the node cache.	
To start the temperature collection, press **1 + ENTER** to select Start. Now enter the required periodic polling period in minutes and press **ENTER**. Next enter the required additional seconds and press **ENTER**.	
Periodic temperature collection will now begin. The most recent temp and time collected will be displayed on the LCD. Furthermore, all readings are stored in memory for future access. If a collected temp falls outside the allowable range, the LCD will display "ALARM!" and the buzzer will turn on. The most recent temp to cause an alarm state will be displayed on the LCD. Both the alarm and the polling routine can be exited by pressing and holding **ENTER** or **CLEAR**.	

3. View data

This option allows the user to view on the LCD the temperatures stored in memory during periodic collection.

Ex: To view the data collected from node 1 you should follow the following sequence.

Power up the BU.	
From the main menu, select option **3** + **ENTER**. You should now have the adjoining screen.	
Now enter the required node number, which for the example is **1**, and press **ENTER.** The LCD will look something like the adjoining screen (Note: Your data would be different.) You may scroll through this display by using ↓ or ↑. If no data is available for the selected node, the LCD will revert to the main menu.	

4. Connect

This option allows a computer to control the base unit. The computer has the capability to download the temperatures and times stored in memory, download the routes to nodes in the network, read and set the base unit's clock, and perform single and periodic temperature collections from individual nodes. The operation of the PC interface will be discussed in the next chapter.

5. Set clock

This option allows the user to read and set the base unit's time and date.
You may use the following steps to perform these tasks.

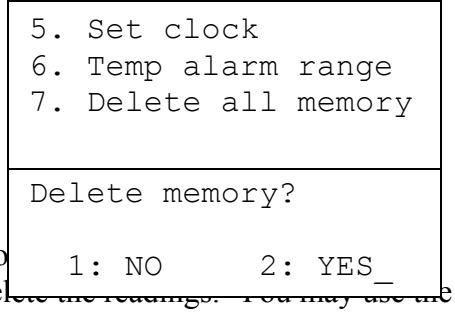
Power up the BU.	1. Node temp 2. Start collection 3. View data 4. Connect
Press ↓ to access the rest of the menu. Now press **5 + ENTER** to access the select clock option. It is also possible to select options 5, 6, and 7 from the screen showing options 1, 2, 3, and 4.	5. Set clock 6. Temp alarm range 7. Delete all memory
Press **1** to return to the main menu, or press **2** to enter the new date and time.	11/17/02 12:53:31 1: OK 2: Set

6. Temp alarm range

This option allows the user to read and set the minimum and maximum acceptable temperatures. If any collected temperature falls outside this range, the alarm will be activated.

Ex: Set the min temperature to -1℃ and the max temp to 40℃.

Power up the BU.	1. Node temp 2. Start collection 3. View data 4. Connect
Press ↓ to access the rest of the menu. Now press **6 + ENTER** to access the temp alarm range option. It is also possible to select options 5, 6, and 7 from the screen showing options 1, 2, 3, and 4.	5. Set clock 6. Temp alarm range 7. Delete all memory
Press **1** to accept the settings and return to the main menu, or press **2** to change the settings. (**2** had been pressed for this example.)	Min temp: 0 C Max temp: 100 C 1: OK 2: Set_
Now enter the minimum temperature in degrees. (*Note: The negative sign is entered by using 2ND*) To set the min temp to -1°C, press **2nd + 1 + ENTER**.	Enter min. temp (C) -1
Now enter the maximum temperature in degrees. (*Note: The negative sign is entered by using 2ND*) To set the max temp to 40°C, press **4 + 0 + ENTER**. The new entries have been saved, and the LCD will revert to the main menu.	Enter max. temp (C) 40



7. Delete all memory

This will delete all stored temperature readings fro temperature collection. This is the only way to delete the readings. You may use the following steps to perform this option.

Power up the BU.	
Press ↓ to access the rest of the menu. Now press **7 + ENTER** to access the delete all memory option. It is also possible to select options 5, 6, and 7 from the screen showing options 1, 2, 3, and 4.	
Select the desired option. The LCD will then revert to the main menu.	

PC Software User Interface

The base unit can be connected to a computer for additional functionality and logging capabilities. Using a Java application, the user can collect node temperatures on demand from an intuitive user interface, as well as setup a standard collection, save collected data to a file, print collected data, or even graph temperatures over time.

The following steps should be followed in order to run this software interface.

- The software should be started up by clicking on the  icon. The initial screen is shown in Figure 2 below.

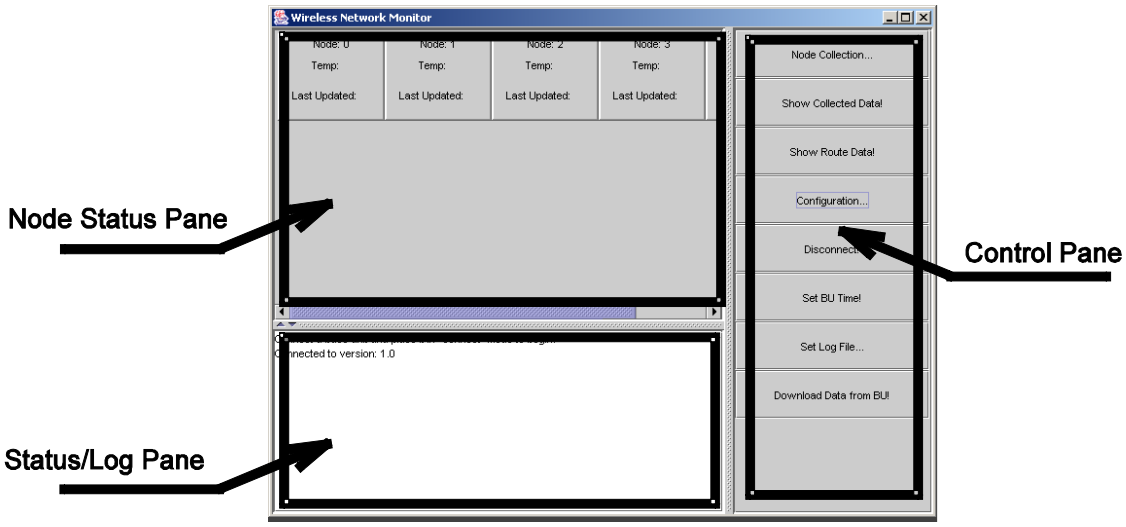


Figure 2: Network monitor screen

This is called the network monitor screen. It is the main screen for the software. There are three main panels:

A. Node Status Pane: - (Upper-Left)

The node status pane displays the results of the last communication with a particular node.

B. Status / Log Pane: - (Lower-Left)

The status / log pane below describes the current status of the program and records actions taken by the program.

C. Control Pane: - (Right)

The control pane is where network configuration is setup and where data is manipulated.

- Connect the base unit to COM 2 via an RS – 232 (DB9) cable as shown in Figure

Figure 3: Connecting of base unit to DB-9 cable

- The PC software initial screen in the status/log pane will display the message **"Connect a base unit and place it in "Connect" mode to begin."** Power up the base unit according to the procedure explained before. The main menu will appear.

- Select option 4 on the base unit to connect to the computer. If the connection is good, you should get the following message on the base unit. Otherwise the base unit will revert to the main menu.

```
Connection Good
```

You will also get a message on the status log plane **"Connect to version: 1.0".** It should be noted that your version number may differ from that shown.

A failed connection may be remedied by:

i. Checking the cable ensuring it has good connections at both ends
ii. Checking the cable to ensure that it is connected to COM 2
iii. Checking to see if any other program still has control over COM 2.

In order to ensure this you, may need to restart the computer.

The use of the PC software interface is illustrated in the example below.
Ex: Assume nodes 0, 1 and 2 are available. However, for this example, only nodes 0 and 2 are functioning. Also, temperatures will be collected periodically every 10 seconds.

Choose "**Configuration**" on the control plane by clicking it. A box similar to Figure 4 will appear.

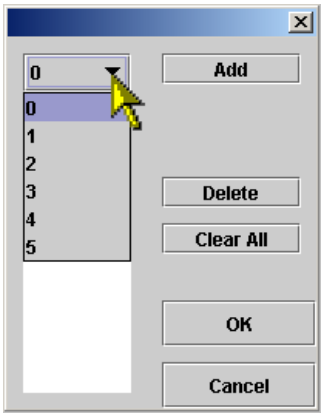


Figure 4: Configuration dialog box

This box is used to add the various nodes available in the network. Do this by first selecting the node number and then clicking the **"Add"** button. For this example, add all the nodes that are required, namely 0, 1 and 2. Once all the nodes have been added, click **"OK"**. Three buttons are now displayed in the status pane. These three buttons correspond to the three nodes that were added.

In order to initiate a one-time collection from a particular node, click the appropriate node button. The collected temp and time will then be displayed on the appropriate button. If the node failed to return a temperature, "NA" will appear in the node's button. An example of this is shown in Figure 5.

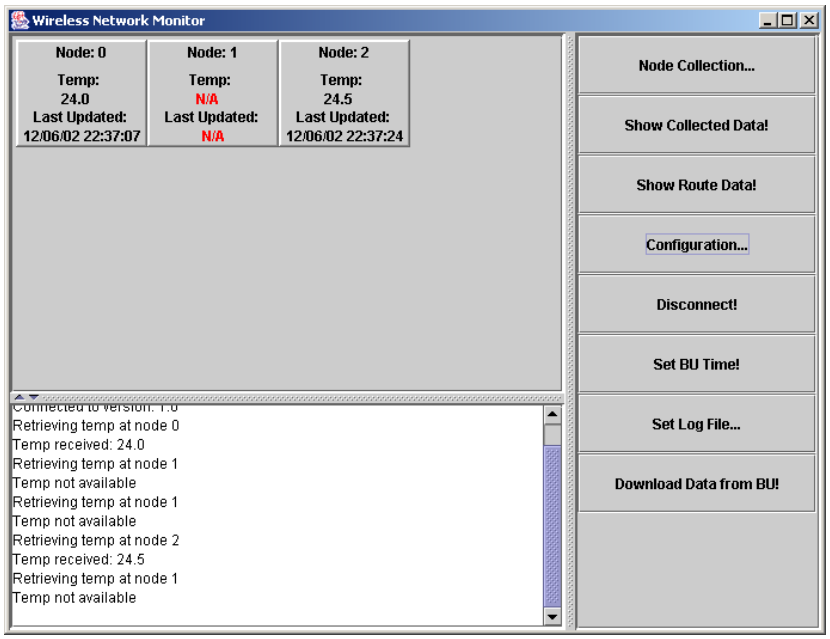
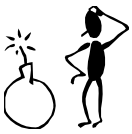


Figure 5: Node polling



If a button displays "NA", it may be due to the following:

i. Low power supply or no power supply to the node (the batteries may be wired up with reverse polarity.)

ii. The node may be out of range from the base unit and all other nodes.

In order to set up the system to periodically collect temperatures, a log file must be created as a place to store the incoming data. This can be done by clicking **"Set Log File"** and entering the name of the log file in the appropriate dialog box that appears. The listings in the log file can be displayed by clicking **"Show Collected Data"** as shown in Figure 6.

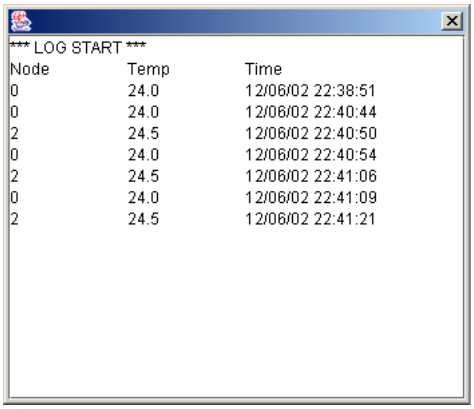


Figure 6: Log file listing

In order to view the network organization for facilitating debugging and to improve efficiency, click on **"Show Route Data!"** to display a window graphically displaying the network topology as shown in Figure 7.

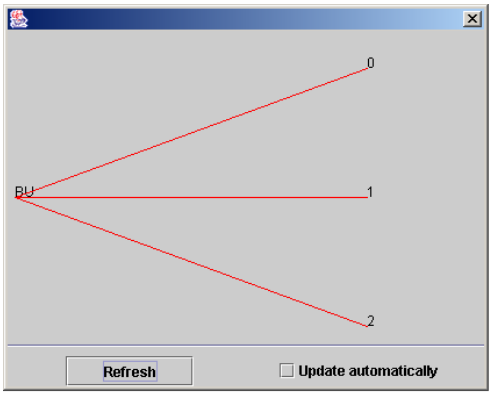


Figure 7: Route data

This diagram does not represent the actual dimensions of the network or the location of components. It only displays the route information that the base unit needs to get to a certain node. (i.e. the intervening nodes that act as relays.)

The next step to collect data periodically from nodes is to set the time interval that it is required to collect temperatures. This is done by selecting **"Node Collection"** as shown in Figure 8. In the dialog box that appears, either enter or select the desired period of collection. The node collection box can also be used to add or delete the nodes setup for periodic collection. Only nodes that were entered during the configuration step can be selected. Selecting OK or Cancel in the node collection box will start or stop the periodic collection.

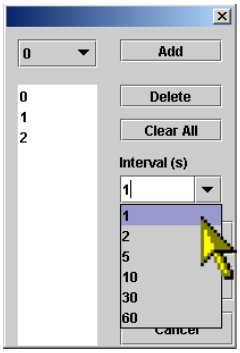


Figure 8: Node collection dialog

- The software interface can be used to download data previously collected by the base unit. This can be done by clicking on **"Download Data from BU!"** A log file must be setup for this step to work. The data can be viewed by selecting "**Show Collected Data!"**

Trouble Shooting FAQ's

How long do the batteries last in the Base Unit and Node Units?
This varies with the frequency of collection that is initiated, hence the amount of use. A conservative estimate for the battery lifespan in the Base Unit is 72 hours and about 360 hours for the Nodes.

The battery in the base unit died. Did I just loose all my data?
No. The data is stored on non volatile EEPROM. Replacing the dead battery will allow access to the data.

Can these sensors transmit through metal casings normally utilized in the refrigeration industry?
Yes. It should be noted that its range tends to decrease when it is required to transmit through metal. Hence this should be taken into account in setting up the network i.e. deciding the location of the nodes.

I have just placed the sensors in the refrigerator and they are reporting a wrong temperature.
The sensors do take some time to warm up or cool down before they take accurate readings. Wait for some more time until the sensors record consistent readings over a period of time before starting the collection.

Can the wireless network affect or be affected by other wireless devices?
Yes, if they are transmitting at the same frequency of 916 MHz. This interference sometimes causes the network to slow down or some parts of the network may be temporarily out of operation. Turn off one of the wireless devices to see if the problem corrects itself.

A certain node in the network has abruptly stopped working. What do I do?
This could be due to one of the following, in the order of their probability of occurrence:

a. Node out of range:
   First, check if the node is within range of the base unit or within range of another working node. Then, manually add it to the network (by using either the base unit or the software interface) and try initiating a one shot collection from it. This will cause the network to specifically try to seek out that particular node. If the system returns with a temperature for that node, then it's back on the network. You can then try to move it away to its desired location. If it quits working again, then it's probably out of range at it new location. Try to move it closer to the base unit or adjust one of the intervening nodes closer to it so that the signal gets a route to the base.

b. Defective power supply:
   If the above procedure does not remedy the problem, check the power supply i.e. if the batteries have been put in with correct polarity or if they are dead. Also check if the wires from the battery to the unit have become loose.
c. Node stalled:
   If the above procedure still fails, disconnect the power supply for that node temporarily and then reconnect it. This resets the microcontroller on the node.

If none of these are the cause, then the unit is not user serviceable.

All of my units are very close to the base unit however my "Display Route Pane" shows that it has to hop to get to a particular node. What should I do?
This is possible in the case when there environment (at the frequency at 916 MHz) is extremely noisy. This may cause the initial packet sent by the base unit to the node to be rejected while the node may accept the retransmitted version of the packet from another node.

This condition should not affect your readings in any way or their timings to any appreciable extent. However, if this still bothers you, you may try to delete this node from the network (and thus deleting its route data) and then add it again. (Causing the network to find a route to the node in question. Hopefully the network should get it right this time.)

I reversed the power supply on one of the nodes (or on the base unit) and the unit will not work after that?
Face it! You have ruined the unit.

Specifications

A brief list of specifications is provided below as reference for the user.

Wireless Range:	
Ideal conditions	~50 feet
Obstructions / noise	~10 feet
Wireless Frequency:	916.5 MHz
Wireless Modulation:	OOK (On Off Keyed)
Operating range:	-40 °C to +70 °C
Temperature accuracy:	accurate to ± 1 °C
Max number of nodes:	127
Max number of hops:	16
Base unit memory:	32k
Power supply:	
Base unit	9V battery or 9V DC input
Node	2 x AA batteries
Battery Life:	
Base unit	~72 hours
Node	~360 hours, depending on frequency of usage
Physical dimensions:	(WxLxH)
Base unit	5 ½" x 7" x 2 ½"
Node	2 ¼" x 3" x 1 ½"